In the gastrula stage when the equatorial band of cilia is formed and the cleavage cavity nearly closed up by the elongated entoderm cells, spin processes were seen at the end opposite to the area of invagination, passing from the ectoderm cells to the membrane where it was slightly raised away from the ectoderm. Here also some movement and change of form was seen in a process, though not satisfactorily. Within the cleavage cavity a moving, pseudopodium-like process appeared to extend out from the entoderm toward the ectoderm, but it could not be seen clearly.

Some of these processes in Serpula, less difficult to see than the finest, presented enlargements, suggesting the probability of slow flowing of material along the process. The increase in number and length of filaments from a definite area under observation for a few minutes showed that they were gradually formed, and from the egg outwards.

Owing to poor light no higher than 8 eye-piece could be used with 2 mm. objective, so that it is probable many phenomena escaped observation.

The occurrence of such filose activity of the surface of the eggs of an animal so widely separated from the echinoderms supports the idea that such phenomena are universally properties of protoplasm,—an hypothesis put forth in a recent work[3] and based not only upon egg, and other, external spinnings, but upon numerous internal protoplasmic phenomena of the same nature, such as spinnings into alveoli of Bütschli's structure in both fluid areas and contractile structures, and contraction and strial displacements of the substance.

E. A. Andrews.

PSYCHOLOGY.[1]

Some Experiments on the Tactual Threshold for the Perception of Two Points.[2]—The term "space-threshold" was applied by Fechner to the distance which two small points must be apart in order to be perceived as two. Weber had already devoted

[3] The Living Substance as Such and as Organism. G. F. Andrews. Gnin & Co. Boston. August, 1897.

[1] Edited by Howard C. Warren, Princeton University, Princeton, N. J.

[2] The first group of experiments described here were reported in the *Philosophische Studien*, 1897, XIII, 163-222, reprinted in *Princeton Contributions to Psychology*, II, 1-60. The second group, viz., those with successive stimuli, will appear in an early number of the *Psychological Review*.

much time to the determination of this distance for different spots on the skin, for he found that the two points must be farther apart, to be felt as two, on some spots than on others. On the bicepts muscle of the upper arm, it is 66 mm.; on the volar side of the forearm, 40 mm.; on the tips of the index fingers less than 2 mm., etc. Many questions arose and many investigators have busied themselves with them; but a number of questions in this field, in spite of the numerous books and articles on the subject, have in some cases received no attention, and in others have not been answered. With the exception of one article, the question as to the threshold for the perception of spatial difference in the case of two *successive* stimuli has never been raised. In experiments with two simultaneously stimulating points, it has long been known that the distance which two points must be apart in order to be perceived as two at any one spot of skin can be reduced in a very marked degree by practice. It was further noticed by Volkmann and Fechner that when this distance is reduced by practice on any one spot, the threshold for the symmetrically opposite spot on the other side of the body undergoes a like reduction without being practiced. These investigators gave a purely physiological explanation of the phenomenon, viz., that the centre in which the two sets of fibres (those from the symmetrical spots) meet is the seat of the change which causes the reduction. Their experiment was not, however, so planned as to test the question whether a similar reduction of this threshold occurs over the entire body.

Our first duty was to undertake a series of such experiments. These were carried out by the writer at the Leipzig Psychological Laboratory. As a result, it proved to be true that the same reduction does occur over the entire body whenever it occurs on any part of the body, and this result points directly to the inference that the whole phenomenon demands a central explanation based upon central psychic processes. But in connection with these experiments several singular phenomena came to light. (1) Not all subjects showed the reduction of the threshold by practice: in fact, it occured only in the cases of those who knew beforehand what the problem was and what results had been hitherto reached by others. In cases where the subject did not know these facts and did not surmise them from the nature of the experiments, no reduction whatever occurred. (2) In all cases where the reduction occurred, there appeared as one result of the practice an increase in the frequency of the illusion called by the Germans *Vexirfehler*, i. e., where the subject senses two points when touched by but one. In cases in which the series began without these illusions, as

with some subjects, the illusion developed after some practice in the experiments. This illusion sometimes becomes so frequent that no thresholds can be determined; the subject answers, in response to all stimuli, whether of one or of two points, "two points." (3) A long series of experiments showed that this illusion is, for the most part, a result of suggestion of some kind; a suggestion which the subject gets either from the operator, from the nature of the experiments, or by auto-suggestion. It was found that the frequency of the illusion, and even its occurrence at all, could be influenced to a marked degree by suggestion. In some cases the illusion could be prevented by the subject's discovering the suggestive influence and freeing himself from it. (4) Subjects were found who, to start with, gave constant thresholds as long as nothing was suggested to them in regard to the object and method of the experiments, but by a suggestion from the operator, they were led to show a very rapid reduction of the threshold. Afterward, by freeing themselves from the influence of the suggestion, they returned, in some cases, to the old constant threshold, freeing themselves at the same time from the illusions which had developed as one result of the suggestion.

All of these facts go to indicate that both the reduction of the threshold by practice and the illusion of two points are the results of suggestion in some form. In every instance of the perception of space relations by touch, there seems to be involved a process of assimilation in which a visual or motor image is the assimilating, and the tactual sensations the assimilated, elements. In ordinary life, we test continually our tactual sensations by visual images, turning the eyes to look at the spot touched. In these experiments this was rendered impossible by the fact that the subject could not see the spot on which the experiments were performed, as this was concealed from him by a screen. Hence the place of these images is supplied by memory images connected with the tactual sensations by past experience, i. e., by association. In our experiments the assimilating visual or motor copies of past experiences are not called up by the association with the tactual sensations alone, but are suggested by other factors. In the localization of a single point, the "local sign" involved is not to be conceived of as a simple quality of the tactual sensation, but is rather a relation of association between the tactual sensation and some visual or motor image.

Another series of experiments was undertaken in the Princeton Laboratory by Dr. C. W. Hodge and myself, in which the two stimuli were successive, instead of simultaneous, as in the above experiments.

In each series of such experiments, the first point touched each time remains the same, the problem being to determine the distance from this point at which the two stimulations seem to be spatially different, and the distance at which the direction of this difference is first recognized. These two determinations may be called the thresholds for *difference* and *direction* respectively. In the results it is found that the subject, as a rule, mistakes the direction of the second point from the first after he has apparently become aware that the two points are not the same. The inference has been drawn that the difference threshold is shorter than the direction threshold. But a careful study of the answers given seems to show that this apparent recognition of difference without direction is again due to suggestion. This entire group of experiments seems to sustain the inferences drawn in the former group as to the ultimate nature of the process involved in all tactual space perception. It is an assimilation process throughout, in which visual, tactual and motor elements play the most important parts. In cases where, as in these experiments, an extensive and rapid reduction of the threshold, and a development of frequent illusions of the kind described, occur as the result of practice, the explanation of these phenomena is to be sought, not in any change in the physiological structure or functions of the tactual end-organs, nor of the centres with which these end-organs communicate, but rather in a process through which suggestion-influences get established in the reactions of the subject's attention.—G. A. TAWNEY, *Beloit College, Wisc.*

The Annee Biologique.—The new annual which has been started by Yves Delage under this title has adopted a broad policy with reference to psychology. The first number (that for 1895) has just appeared, and we are pleased to note that a large section, of over 100 pages, is devoted to this department under the head of "Mental Functions." A portion of this space is taken up with an able review of recent theories of the structure of the nervous system, by Mlle. W. Szczawinsky, but most of the section lies within the domain of psychology proper. Prof. Binet furnishes a review of the development of experimental methods, which, though necessarily brief, contains a fair résumé of the change that has come over this field within the past few years. He sums up, in particular, the work on memory, the æsthetic sense, and the physiological concomitants of mental activity, where considerable progress was made in the year 1895. The remainder of the section consists of summaries by various writers of the leading works and articles which appeared during that year. These are, in some cases, very full; about sixty contributions are noticed in all.

As the scope of the *Année* is purely biological, psychologists have certainly no ground to complain of the treatment which their science receives: the entire section is conceived in a spirit entirely friendly to its claims as a distinct science, and is written for the most part by persons who rank high in the department. If any criticism were to be offered, it would be that it is not perfectly clear why certain departments of psychology that are not mentioned do not deserve treatment in this connection fully as much as certain others that are admitted. But to suggest this would be to look a fine gift horse in the mouth, and we can do no better than express our delight at the whole-hearted recognition which the older science has here accorded to the newer. It is to be hoped that the plans of the *Année biologique* will not be altered in this respect, and that in future the psychologist may always be able to trace the progress of research on the biological side of his department by simple reference to the pages of this annual.—H. C. W.

ANTHROPOLOGY.[1]

The Tomahawk of the North American Indian.—In regard to your inquiries concerning tomahawks in the United States National Museum I would say that, in order to understand their structure, their function and the places which they supplied in the armory of the Indians of the United States it is best to remember the following facts: Aborigines of this Continent seem to have understood all the ways of killing men and animals. Before the discovery they used both poison and fire to take life, and they had the three great types of weapons, namely: for bruising, for piercing and for cutting. Adrien de Mortillet somewhere calls attention to the additional fact that each one of these classes of weapons, to-wit: bruising, piercing and cutting, is used in the hand, at the end of a handle, or thrown from the hand. You will see that underlying this division of Mortillet's we have three methods of applying force. First, directly utilizing the explosive force of human muscle. Secondly, the additional impetus given to a weighty weapon by affording it a longer excursion in the air and the added element of safety in that by means of a long handled bruiser, piercer or cutter the attacking one produces his effect at a greater distance from himself. The ballistic weapon, seldom thrown from the hand alone, acquires its velocity and additional force by means of a sling, throwing stick or a bow.

[1] This department is edited by H. C. Mercer, University of Pennsylvania.